Question Number	Answer	Mark
1(a)	This can be marked in terms of the train either initially stationary or moving with constant speed. State N1in terms of ΣF =/> 0 e.g. An unbalanced/net/resultant/total/ΣF force of zero gives constant speed/velocity/motion **(1)** (the friction between floor and feet) accelerate the feet **Or** (friction between floor and feet) creates an unbalanced/net/resultant/total force on feet **(1)** the train accelerates but the man continues travelling at the original/constant speed **Or** the top half has no (resultant) force as the train accelerates **Or** the man's speed relative to the train is lower **Or** (All of the) man needs to accelerate at the same rate as the train **(1)**	**3**
***1(b)**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) Man pulls (backward) on the support **(1)** Due to N3 the support exerts a (opposite) force on the man **(1)** This force is a resultant/unbalanced/net force on man **(1)** Due to N1/N2 the man will accelerate **(1)** With the same acceleration/speed/velocity as the train **(1)**	**5**
	Total for question	**8**

Question Number	Answer		Mark
2	See: W = mg **OR** newton unit of force **OR** newton unit of weight	**(1)**	
	W = 0.98 N or W = 0.1 (kg) x 9.81 (N kg^{-1}) = 1 N	**(1)**	
	See: W = Fs **OR** gpe = Wh **OR** gpe = mgh **OR** joule unit of energy	**(1)**	
	Gpe = 0.98 J	**(1)**	
	See: P = W/t or variation **OR** watt unit of power	**(1)**	
	P = 0.98 W	**(1)**	**6**
	Total for question		**6**

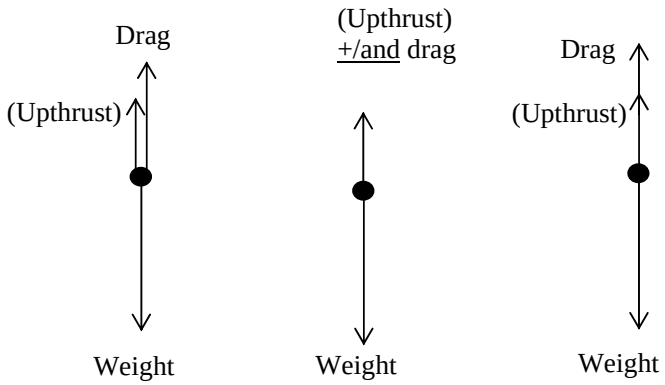
Question Number	Answer	Mark
3 (a)	Use Newton's laws 1 and 3 to explain motion	
	Uses N3 – force (backward) on air by balloon/car, (so/=) force (forward) on balloon/car by air	**(1)**
	Uses N1 – resultant force / forces unbalanced / force on balloon > drag, (so) there is an acceleration / moves from rest / starts moving	**(1)**
	Identifies the use of N1 or N3 (by name or description) correctly, linking it to the context	**(1)**
3 (b) (i)	Show that maximum speed is between 100 and 150 cm s^{-1}	
	Draw tangent on graph / state use gradient / show use of gradient	**(1)**
	Identify max speed between 1.2 and 1.4 s (from position of gradient or values used)	**(1)**
	Correct answer (120 (cm s^{-1}))	**(1)**
	Example of calculation v = 120 cm – 0 cm / 1.9 s – 0.9 s = 120 cm s^{-1} (allow answers which are in range 100 and 150 cm s^{-1} when rounded to 2 sf)	
3 (b) (ii)	Sketch graph	
	Shows:	
	Speed increasing from 0 and then decreases	**(1)**
	Max speed at correct time (accept between 1.0 and 1.5 s) OR correct magnitude (must be indicated)	**(1)**
	Speed decreasing to 0 at between 3.4 and 4.0 s	**(1)**
	Total for question	**9**

Question Number	Answer	Mark
4(a) (i)	Label the diagram Upthrust / *U* – upward arrow [accept buoyancy force] (1) Viscous drag / drag / friction / *F* / *V* / *D* – downward arrow [accept water resistance](1) [Arrows do not have to be on the bubble]	**2**
4(a) (ii)	Explain why a steady upwards speed is reached. Initially viscous drag = 0 / is very small / resultant force is upwards / $U > W$ / $U > W + F$ (1) Viscous drag increases (1) (Until) forces balanced (1) Therefore: no acceleration / uniform velocity / terminal velocity / const speed (1) Must be a clear link to balanced forces to allow mark 4, even if mark 3 not awarded	**4**
4(a) (iii)	Write an expression for the forces (-) Upthrust = Viscous drag + Weight; Upthrust + Viscous drag + Weight = 0 (1) [Allow ecf from diagram] [Accept symbols]	**1**
4(b) (i)	Justify decision to ignore weight of air Density of air much less than density of (any) liquid (1) So weight << upthrust / weight << viscous drag / weight << other forces(1) (not consequential) ('W negligible' alone not sufficient)	**2**
4(b) (ii)	Explain what would happen if temperature increased viscosity decreases (1) speed/velocity would be greater (1)	**2**
4(b) (iii)	Use expression to explain larger bubble catching smaller bubble If r increases so speed increases (1)	**1**
	Total for question	**12**

Question Number	Answer	Mark
5(a)	Force diagram Accept free body or triangle/parallelogram of forces Downward arrow labelled Weight/*W*/*mg* (1) Arrows parallel to both lines, at least one labelled tension/*T*(1) Minus 1 for each additional force	**2**
5(b) (i)	Show that downward vertical force is about 11 N Correct answer (10.8 N) (1) [no ue] *Example of calculation* $W = mg$ $= 1.1 \text{ kg} \times 9.81 \text{ N kg}^{-1}$ $= 10.8 \text{ N}$	**1**
5(b)(ii)	Show that the angle is about 84°. Correct use of sides in right angled triangle (1) Correct answer [84.2°] (1) [no ue] *Example of calculation* $\tan \theta = 4.80 \text{ m} / 0.485 \text{ m}$ Angle = 84.2° (Accept use of cos instead of tan)	**2**

5(b) (iii)	Show that the tension on the line is less than 60 N Use of trigonometrical function for vertical component of tension (1) Correct answer [53 N] (1) [allow ecf] [no ue] Example of calculation $T_v = T \cos \theta$ $W = 2\ T \cos \theta$ T = 10.8 N / 2 x cos 84.2 = 53.4 N Alternative answers range from 51 N to 55 N	**2**
5b) (iv)	Calculate the strain Calculate extension (1) correct answer [2.6×10^{-2}] (1) *Example of calculation* extension = 9.847 m – 9.6 m = 0.247 m strain = 0.247 m / 9.6 m = 2.6×10^{-2} [2.6%]	**2**
5(c)	Calculate Young's modulus Use of stress = force / area (1) Use of E = stress / strain (1) Correct answer [3.1×10^8 Pa] [3.1×10^8 N m^{-2}] (1) [allow ecf, including use of F = 60 N] [Substituting into $E = (F/A)/(e/l)$ in one go gets both use of marks] $E = (F/A)/(e/l)$ = (53.4 N / 6.6×10^{-6} m^2) / 2.6×10^{-2} = 3.1×10^8 Pa (accept answers in range 3.0×10^8 Pa to 3.6×10^8 Pa for alternative F values)	**3**
	Total for question	**12**

Question Number	Answer		Mark
6(a)	$mg = ma$ either leading to a = g or a statement that the masses cancel	(1)	**1**
	Example of answer $F = ma$ and $W = mg$ $mg = ma$ $a = g$		
6(b)(i)	$s = ½at^2$ **Or** $a = 2s/t^2$ **Or** $s = ut + ½ at^2$ **and** $u = 0$	(1)	**1**
	(allow g for a and h for s)		
6(b)(ii)	**Either**		
	Parallax(in measuring s) **Or** the ruler was not vertical/perpendicular	(1)	
	Giving a larger value for s (than the actual value)	(1)	
	Or		
	The frame rate was incorrect **Or** the idea that the initial velocity of the ball was not zero	(1)	
	Giving a lower value for the measured time	(1)	**2**
	Examples The ball was dropped before the camera started recording or the ball was dropped before the first frame or the ball was dropped from above the ruler. (Do not accept ball was thrown)		
	Total for Question		**4**

Question Number	Answer	Mark
7(a)(i)	Weight **Or** *W* **Or** *mg* (1) (Viscous) drag **Or** (air)resistance **Or** *D* (1) Minus 1 for additional forces except electric forces  	**2**
7(a)(ii)	Drag increases as the velocity increases **Or** the velocity of the drop increases and the drag is proportional to velocity(^{2}) (1) Resultant/total force becomes zero **Or** weight − drag − upthrust = 0 **Or** forces balance (1) (Do not accept $\Sigma F = 0$ unless F is defined) (ecf incorrect label only but not incorrect direction or forces from (a)(i) in a stated equation)	**2**